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RESEARCH ARTICLE

Comparison of the Sealing Ability of Biodentine, iRoot BP Plus and Mineral Trioxide Aggregate

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ABSTRACT

Objective: The aim of this study was to compare the sealing ability of two new root repair materials, Biodentine and iRoot BP Plus against ProRoot MTA when used as root-end fillings.

Methods: The root canals of 45 extracted maxillary anterior teeth were prepared with ProTaper instruments. After apical resection and ultrasonic root-end cavity preparation, the teeth were divided into three groups. The cavities in the first group of 15 were filled with Biodentine, the second with iRoot BP Plus and the third with ProRoot MTA. A computerized fluid filtration method assessed the seal at 2, 10 and 28 days.

Results: Significant differences were found between Groups 1-2, Groups 1-3 and between Groups 2-3 at all-time intervals ($P < 0.05$). Leakage was not significantly different at 10 and 28 days for Biodentine and iRoot BP Plus ($P > 0.05$).

Conclusion: The two new root repair materials showed good performance and both offered improved handling properties compared to MTA.

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INTRODUCTION

Despite the success of root canal treatment being high[1] failed cases arise where teeth cannot be retreated conservatively and endodontic surgery is required. The root tip of the tooth is resected perpendicular to its long axis with 3 mm commonly removed, and then a root-end cavity 3 mm deep is prepared and filled. Resection allows accessory canals and ledged and altered root morphology to be addressed, and the root-end filling aims to prevent the passage of any residual microbial products from the root canal to the periapical tissues[2]. Many materials have been proposed for root-end fillings, including amalgam, gutta-percha, zinc oxide–eugenol, polycarboxylate, glass ionomer and composite resin cements, IRM, Super-EBA and more recently mineral trioxide aggregate (MTA)[3-8]. MTA demonstrates superior sealing ability and biocompatibility compared to many other materials[7-11], however its handling characteristics and slow setting time make it challenging to use[12]. To reduce or eliminate these problems new materials have been introduced. According to the manufacturer, iRoot BP Plus Root Repair Material (Innovative BioCeramix, Vancouver, Canada) is a convenient and ready-to-use white hydraulic bioceramic putty developed for permanent root canal repair and surgical applications. It is an insoluble, radiopaque and aluminium-free material based on a calcium silicate composition, requiring the presence of water to set. It claims to not shrink during setting and to have excellent physical properties. It is packaged premixed in a container. Biodentine (Septodont, Maidstone, UK) is a calcium silicate-based material intended as a dentine substitute, developed to circumvent the shortcomings of traditional filling materials. It is composed of Ca_3SiO_5, $CaCO_3$, ZrO_2, water and a superplasticizing admixture to reduce the water content of the mix and to retain its workability. This material is presented as a powder and liquid, is prepared in an amalgamator and has a setting time of 10 minutes.[13]

In this study we compared the sealing properties of these new materials with ProRoot MTA when used as root-end fillings.

MATERIALS AND METHODS

Forty-five extracted maxillary anterior human teeth were used. The teeth had been extracted following appropriate consent procedures, and were from hospital dental department collections. Their crowns were removed at the cemento- enamel junction. A size of 15 K-file (Mani Inc., Tochigi-Ken, Japan) was placed passively until it reached the apical foramen under magnification 2.5X (Heine USA Ltd, Dover, USA). The working lenth was established as 0.5 mm shorter than the meausered length. Their canals prepared with ProTaper instruments SX, S1, S2, F1, F2 to finishing file F3 (Dentsply/Maillefer, Ballaigues, Switzerland). Irrigation was copious throughout with 2.5% sodium hypochlorite (NaOCl) solution and a 19% EDTA lubricant (MD-ChelCream, Meta Biomed Inc., Chungbuk, Korea). A final rinse was carried out using normal saline.

The apical 3 mm of the roots were resected at an angle of 90 degrees to the long axis of the root with tungsten carbide fissure burs (HM 31L 010, Meisinger, Neuss,Germany) and 3 mm deep root- end cavities were cut with zirconium nitride-coated ultrasonic retrotips (ProUltra Tip No. SURG 1,) Dentsply/Maillefer) powered by an ultrasonic generator (EMS, Nyon, Switzerland). A medium power setting was selected with water cooling, and all preparations were made by a single operator. The roots were supported in a

silicone-lined jig to simulate periodontium and the cavities measured with a periodontal probe to ensure consistent depth (PCPUNC15, Hu-Friedy, Chicago, IL, USA). A new retrotip was used for every 10 cavities. The cavities were irrigated with NaOCl, rinsed with normal saline and dried with paper points. The roots were randomly divided into three groups. The cavities of the first group were filled with Biodentine, the second group with iRoot BP Plus and the third group with white ProRoot MTA (Dentsply/Tulsa Dental, Tulsa, OK, USA). The fillings were placed by a single operator and their quality was verified with buccolingual and mesiodistal radiographs.

The teeth were stored at 37°C and 100% humidity during the experiment and the sealing effectiveness assessed using a fluid filtration method at 2, 10 and 28 days. The apical thirds of the roots were cemented into a plastic tube with cyanoacrylate adhesive (Zapit, Dental Ventures of America Inc., Corona, CA, USA). They were then connected using 18-gauge stainless steel tubing to a computerized fluid filtration system featuring a 25 µL micropipette mounted horizontally (Microcaps, Fisher Scientific, Philadelphia, PA, USA). The apparatus was filled with distilled water and an air bubble created in the micropipette. A constant pressure of oxygen at 120 kPa was applied from the apical side and maintained with a digital air pressure regulator (DP-42 Digital pressure and vacuum sensor, Sunx Sensors, Des Moines, IA, USA). The system was pressurized for 5 minutes before recording commenced. The computerized fluid filtration meter used refraction of infrared laser light and photodiodes to track movements of the bubble. All operations were controlled with PC-compatible software (Fluid Filtration 03, Konya, Turkey). Leakage was expressed in $\mu L/cmH_2O/min^{-1}$ and means determined. Data were analyzed using SPSS 11.5 (SPSS Inc, Chicago, IL, USA) using the Kruskal-Wallis and Wilcoxon Signed-Rank tests. A P value equal to or less than 0.05 was accepted as significant.

RESULTS

Mean microleakage measurements and standard deviations are shown in Table 1. A significant difference was detected among the groups at each time interval ($P < 0.05$).

Table 1. Mean fluid filtration measurements (values expressed as $\mu L/cmH_2O/min^{-1}$ at 120 kPa)

Groups (n=15)	**2nd day (Mean±SD)**	**10th day (Mean±SD)**	**28th day (Mean±SD)**
Biodentine (Group 1)	0.0001285 ± 0.000048	0.0005387 ± 0.0005590	0.000681 ± 0.000690
iRoot BP Plus (Group 2)	0.0004626 ± 0.000245	0.0000918 ± 0.0000636	0.000100 ± 0.000096
MTA (Group 3)	0.0007718 ± 0.000711	0.0000509 ± 0.0000470	0.000180 ± 0.000183
P	0.000	0.000	0.000

Kruskal-Wallis test

Significant differences were found between Groups 1-2, Groups 1-3 and Groups 2-3 on day 2 (P = 0.001, P = 0.000 and P = 0.003 respectively). On day 10 significant differences were found between Groups 1-2, Groups 1-3 and Groups 2-3 (P = 0.000, P = 0.000 and P = 0.036 respectively). Significant differences were also found between Groups 1-2, Groups 1-3 and Groups 2-3 (P = 0.000, P = 0.000 and P = 0.016 respectively) on day 28.

When the results at days 10 and 28 were compared there were no significant differences for the Biodentine (P = 0.152) and iRoot BP Plus groups (P = 0.925) (Table 2).

Biodentine showed the least leakage on day 2 and iRoot BP Plus and MTA featured the least leakage on day 10.

DISCUSSION

The success of endodontic surgery has improved with the introduction of the operating microscope, ultrasonics and new root-end filling materials[14].

The quality of the root-end seal is important.[15] An array of restorative materials have been used [16] with MTA introduced specifically for root-end filling and perforation repair.[16, 17] It has become the gold standard root-end filling material.[11] It demonstrates a superior seal and biocompatibility when compared to other materials[11, 18], but its mixing and placement characteristics and slow set make it challenging to use. Biodentine was developed as a dentine substitute and exhibits similar excellent biological properties to MTA[13].

Leakage remains important when evaluating root-end filling materials[8] and we used the computerized fluid filtration method which overcomes the disadvantages of previous techniques.[19] Samples are not destroyed and measurements can be recorded over extended time periods. In addition, conventional fluid filtration measurements reflect the leakage of the entire sample and are quantitative.[20] In the past these measurements were reliant on visual readings. The reliable computerized, fully electronic and digital air pressure monitoring system used in this experiment overcame this problem and has been used previously to investigate the leakage of MTA in root canals.[21]

Leal et al [22] compared the ability of Ceramicrete (Dentsply/Tulsa Dental), DiaRoot BioAggregate (Innovative BioCeramix) and white ProRoot MTA to prevent glucose leakage through root-end fillings on the third day. Both these repair cements displayed similar leakage results to the MTA. In our study, iRoot BP

Table 2. Comparison of sealing ability with time.

Measurement days	**P**		
	Group 1 (Biodentine)	**Group 2 (iRoot BP Plus)**	**Group 3 (MTA)**
2nd day -10th day	0.005*	0.020*	0.001*
2nd day -28th day	0.004*	0.040*	0.001*
10th day -28th day	0.1520	0.9250	0.002*

Wilcoxon Signed-Rank test

Plus bioceramic showed significantly less leakage than MTA on day two. However, on the 10th day, MTA showed significantly less leakage. This change in seal with time could be related to MTA's setting reaction, as its maturation and resistance to dislodgement gradually increases.[18] However, on the 28th day MTA showed more leakage than on day 10. The compressive strength of MTA has been reported to increase in the presence of moisture for up to 21 days[23] , which may be related to leakage over time. We measured leakage on 2nd, 10th and 28th days to compare the effect of time on the leakage of the materials.

As an *in vitro* study with extracted teeth our study has limitations. Among these is the periodontal ligament, which in life acts as an energy-absorbing system when preparing cavities ultrasonically[24]. We supported the roots in a jig to simulate the ligament.

The results of this study show positive performances by Biodentine and iRoot BP Plus *in vitro*, suggesting these new root-end filling materials with easy and efficient delivery have potential. However, the clinical implications need to be investigated, as the literature lacks well-designed, prospective clinical studies comparing them to MTA, and indeed of MTA itself.

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